AAMA
American Automobile Manufacturers Association

1401 H Street, N.W., Suite 900 • Washington, D.C. 20005
Tel. No. 202-326-5500 • Fax No. 202-326-5567

Andrew H. Card, Jr.
President and Chief Executive Officer

February 3, 1994

Secretary
Federal Communications Commission
Washington, D.C. 20554

Re: Comments of American Automobile Manufacturers Association on Spectrum Needs and Recommendations for Vehicular Radar Devices (RM-8308)

Attached is an original and nine copies of the American Automobile Manufacturers Association (AAMA) comments on rulemaking RM-8308. Also included with the AAMA comments is a Motion for Acceptance of Late Filed Comments.

We believe the attached comments will add substantial information and help the Commission staff in their deliberations of millimeter wave spectrum requirements.

Please contact Ron Wasko of my staff at (313) 871-6335 if you require additional information concerning any aspects of the AAMA comments.

Very truly yours,

Vann H. Wilber, Director
Vehicle Safety and International

Attachments (3)

cc: Richard Engleman, Chief, Technical Standards Branch
Julius Knapp, Chief, Authorization and Evaluation Div.
John Reed, Engineer, Technical Standards Branch
Thomas Stanley, Chief Engineer, Engineering and Tech.
William Torak, Office of Engineering and Tech.
David R. Siddall, Office of Engineering and Tech.

Before the
Federal Communications Commission
Washington, D.C. 20554

February 3, 1994

In the matter of:	)	
	)	
Rulemaking to Permit	)	RM-8308
Use of the 76-77 GHz Band for	)	
Vehicle Radar Systems	)	

To: Secretary, FCC

MOTION FOR ACCEPTANCE OF LATE FILED COMMENTS

Pursuant to Section 1.45 of the Rules,[1] the American Automobile Manufacturers Association (AAMA) hereby files the attached comments in the above-captioned proceeding. The AAMA is the trade association of the American automobile industry, whose members are: Chrysler Corporation, Ford Motor Company, and General Motors Corporation. In support of the foregoing, the following is shown.

On July 12, 1993, General Motors Research Corporation (GM) filed a petition for rulemaking requesting that the Commission allocate 1 GHz at 76-77 GHz for use by automotive radar systems. At the time this document was filed, the AAMA was in the process of identifying industry-wide requirements for automobile radar needs into the 21st century. The AAMA work was not finalized at that time, and could not be provided.

Now, however, the AAMA has completed its work. The attached comments reflect broad based agreement, and a common understanding, of the American automotive industry regarding the need for safety-related radar RF spectrum allocations. Because manufacturers anticipate offering vehicular radar systems in the near future, the AAMA requests the Commission to begin the process of frequency allocation as soon as possible.

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[1] 47 C.F.R. § 1.45(c) (1992)

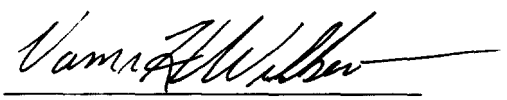
The attached comments are intended to provide the Commission essential, and more specific, supplemental information about the needs of the American automobile industry on this subject. The Commission can also use this information in the context of any other proceedings it may be contemplating to address millimeter wave frequency allocations. As such, these comments will provide a more complete record for agency decision-making.

The AAMA will also serve the attached comments on all parties in this proceeding, who will then have the opportunity to address any issues raised.

Accordingly, AAMA urges the Commission to accept the attached comments that explain the important spectrum requirements of the U.S. automotive industry for safety-enhancing radar.

Respectfully submitted,

AMERICAN AUTOMOBILE
MANUFACTURERS ASSOCIATION

By 

February 3, 1994

Attachments (2)

Before the
Federal Communications Commission
Washington, D.C. 20554

February 3, 1994

In the matter of:	)	
	)	
Rulemaking to Permit	)	RM-8308
Use of the 76-77 GHz Band for	)	
Vehicle Radar Systems	)	

Comments of American Automobile Manufacturers Association --

Preliminary Requirements and Recommendations for

Vehicle Radar Devices

1.0 INTRODUCTION

The American Automobile Manufacturers Association (AAMA), whose members are Chrysler Corporation, Ford Motor Company, and General Motors Corporation, submits these comments concerning vehicle radar system spectrum needs, including the use of the 76-77 GHz band proposed in the Petition for Rulemaking filed by General Motors Research Corporation. These comments result from work done by AAMA Intelligent Vehicle Highway System (IVHS) Electromagnetic Spectrum Task Group which was formed by AAMA in March of 1993 to investigate spectrum needs for IVHS applications. Automotive radar systems are close to commercial realization, and the development of marketable systems for use by the public depends on millimeter wave transmissions for which new specifications need to be established. Therefore a regulatory approach with respect to use of

millimeter wave spectrum must be adopted to accommodate the emerging vehicle radar technologies. The AAMA comments on the inclusion of new bands for automotive radar applications should not preclude the use of previously approved frequency bands for such automotive radar applications below or within the millimeter wave region.

The deployment of vehicle radar systems is in the public interest due to expected potential beneficial impact on motor vehicle safety, driver convenience, reduced traffic congestion (thus reducing fuel consumption), and reduced insurance costs. Forward-looking, side-looking, and rear-looking radar systems are currently envisioned.

Forward-looking systems include such applications as radar cruise control, collision warning, and collision avoidance. Radar cruise control systems improve the performance of conventional speed control systems by automatically adjusting vehicle speed based on traffic ahead. In a typical collision warning system, objects forward of the vehicle are detected and their trajectory determined. The object's trajectory is compared to that of the vehicle and the driver is warned of an impending collision. In a collision avoidance system, the control of the vehicle (e.g., braking) could be automatically affected in response to an impending collision.

Forward-looking systems will require high resolution (angular and range) and accuracy. The angular resolution of a radar depends on the antenna aperture and transmitter frequency. Specifically, a fine angular resolution requires either a large aperture or a high frequency. Good range resolution depends on having a large signal bandwidth.

Packaging of the sensor and other components within the vehicle, limits the aperture size for the antenna. The antenna would almost invariably be located in the grille and must, therefore, be small in size due to airflow and styling considerations. Consequently, high frequency transmissions are required to obtain sufficient angular resolution.

Side-looking and rear-looking radar systems will provide obstacle detection by

monitoring objects in areas where the driver has reduced direct visibility. Visual displays and audible tones may be used to alert the driver to detected objects. These systems will typically employ lower angular resolution than forward-looking systems and will be easier to package on the vehicle since smaller antenna apertures can be used even at lower frequencies.

Vehicular radar will incorporate existing radar technologies and will utilize many well known and understood techniques. Both pulsed and continuous-wave radars are anticipated. Many different types of modulation schemes will be possible including signal matching and spread spectrum techniques. The ability of systems using these modulation techniques to withstand co-channel and adjacent channel interference is known (see Section 2.3). Thus, each individual radar system would respond only to its own transmitted signals even with other similar or identical systems in its vicinity or even in its direct line of sight.

The specific spectrum needs and standards that have been formulated by AAMA are presented in Section 2. Sufficient spectrum is requested to accommodate the unique requirements of all the separate types of vehicle radar that will provide public benefits. AAMA endorses the concept of open entry for many users of the authorized spectrum and this has been the objective in defining the needs and standards given in Section 2. For example, it is not recommended that any particular modulation scheme be imposed under the regulations.

AAMA members are taking great precautions to minimize false alarms in their vehicle radar systems by using low probability of intercept (LPI) waveforms and special signal processing algorithms, described in more detail below. However, AAMA does not believe there is any need to prescribe by regulations any particular type of modulation or signal parameters other than those contained in Section 2. Good engineering design is capable of minimizing interference between vehicular radar systems.

Even though AAMA members have determined that interference between vehicle

radar systems is highly unlikely due to special precautions being taken in waveform and/or modulation selection, the potential for interference from other sources must be minimized whenever possible because these systems impact vehicle occupant safety. Since an automobile radar system could be operated on any road in the U.S., all possible interfering sources anywhere in the U.S. would have to be identified and examined. Of special concern are any future high power licensed transmitters which might affect the extremely low power vehicle radar systems. Primary spectrum use for vehicle radar will increase public protection from potential false alarms or other malfunctions. Since it is not possible to anticipate all types of uses that might be made of a frequency band authorized for any and all technologies, AAMA strongly recommends that spectrum be restricted to vehicle radar applications (at least for systems operating above 77 GHz) to minimize chances of interference from sources that cannot be characterized in advance. If this is not acceptable, then analysis and tests should be done to determine in each case whether there may be interference between a proposed new user in the spectrum and already established users.

With regard to a licensing methodology, AAMA believes allocation and unlicensed use under Part 15 might be workable if 1) the allocation was limited to vehicle radar applications and 2) no licensed service is or will be authorized at the same frequencies. However, since Part 15 provides no guarantee against primary users of the same spectrum, a better approach would be a primary exclusive allocation. Given the expected number of end users being in the millions, however, this would not be practical if individual licenses were required. Therefore, the AAMA prefers unlicensed or blanket licensed alternatives to Part 15 such as a creation of a vehicle radar service.

AAMA supports the spectrum allocation request of the General Motors petition, RM-8308. Further, AAMA proposes that additional spectrum, emission levels (fundamental, harmonics, and spurious), and testing as described in Section 2 be included in rules to be adopted by the FCC to permit public benefit from vehicle radar systems. The resulting innovations in motor vehicle safety, convenience, and traffic management will help build the foundation of the IVHS environment and will serve the public interest well into the next

century.

2.0 IVHS MILLIMETER WAVE ELECTROMAGNETIC SPECTRUM NEEDS

The following are AAMA's collective electromagnetic (EM) spectrum needs for forward, side, and rear-looking automobile radar systems as defined by the AAMA IVHS EM Spectrum Task Group consisting of technical representatives from Chrysler Corporation, Ford Motor Company, and General Motors. Granting these requests will enable AAMA members to provide the driving public with a broad range of design performance and cost options.

2.1 FREQUENCY BANDS AND OPERATIONAL LIMITS

The frequency bands and suggested operating limits, all of which are requested for use by vehicular radar systems, are listed in Table 2.1. Granting these frequencies would allow all AAMA members to continue their ongoing development of vehicle radar systems.

TABLE 2.1

FREQUENCY BAND (Ghz)	MAXIMUM AVERAGE TRANSMITTER POWER AT THE ANTENNA PORT (mW)	MAXIMUM IN-BAND & OUT-OF-BAND SPURIOUS PEAK POWER (mW)	NOTES
24.75 to 25.25	10	0.01	4,5,6
37.5 to 38.5	10	0.01	4,5
76 to 77	40	0.1	2,3,4
a 1 GHz band between 92 & 95 excluding 93.07 to 93.27	50	0.1	1,2,3,4
139 to 141	100	0.1	2,3,4
152 to 154	100	0.1	2,3,4

NOTE 1: *The government use of 92 to 95 GHz is unknown at this time. AAMA requests a 1GHz band in that range as determined by the FCC working with other government agencies.*

NOTE 2: *Peak power levels shall not exceed 10 dB above the average power values listed. The listed transmitter power levels are predicated on using an antenna with a directional gain no greater than 45 dBi. If a transmitting antenna with directional gain greater than 45 dBi is used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 45 dBi.*

NOTE 3: *The power levels are required to permit ranging up to 250-300 meters. As frequencies increase, to maintain the same radar operating range, the required power must increase (range equation $1/\lambda^2$).*

NOTE 4: *AAMA recognizes ANSI C95.1 (1993) as the appropriate levels for human exposure to radiated fields.*

NOTE 5: *The listed transmitter power levels are predicated on using an antenna with a directional gain of no more than 20 dBi. If a transmitting antenna with a directional gain greater than 20dBi is used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 20 dBi.*

NOTE 6: *See letter from FCC Chief Engineer Thomas Stanley to Susan Wing, Counsel for Vorad Safety Systems, Inc. of Sept. 20, 1993 [Reference 310 30/EQU/6-3] granting Vorad a limited duration waiver for the use of 27.725 GHz $\pm$25Mhz.*

The above bands have been selected based on parametric analyses, system packaging,

cost effectiveness, and marketability. All four areas contribute to the frequency selection process, with system packaging being the primary consideration (a vehicle radar must be integrated in an automobile; if not, the other factors become meaningless). Consequently, the higher frequency bands of 140 and 153 GHz are critical to the future success of radar systems since they facilitate small sized antenna apertures that can be packaged on a vehicle.

Presently, the 10 GHz and 24 GHz bands are being used by some of our members for very short range systems; the 37.5 to 38.5 GHz band has also been selected for very short range systems (on the order of 2 to 20 meters), such as backup warning and lane change warning. These bands permit manufacturing of lower cost devices as compared to devices operating at 76 and 94 GHz. Side-looking and rear-looking systems use broad beamwidths and do not require shorter wavelengths to achieve antenna apertures that can be integrated in a vehicle. Furthermore, radar devices operating in this band may very likely have the capacity to share spectrum with other services.

The remaining bands discussed below are for forward looking systems such as radar cruise control, collision warning systems, and vision enhancement systems.

The 76 to 77 GHz band has been selected primarily due to its proposed acceptance in the European Community and the benefits of commonality. The U.S. and European monolithic microwave integrated circuit (MMIC) industry have already developed MMIC devices at this frequency that can be used to facilitate cost effective vehicle radar systems.

The band in the 92 to 95 GHz spectrum allows an aperture size reduction of 25% relative to the 76 GHz band. This is significant from an automobile packaging standpoint. In addition, high volume, low cost 94 GHz components generated for commercial use would also benefit U.S. defense industry applications (i.e., dual use technologies).[2]

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[2] *Integrated Transceiver Scans W-Band*, Microwaves & RF, September 1993; pages 164-168

The remaining two bands, 139 to 141 GHz and 152 to 154 GHz, have also been selected as operating frequencies for forward radar systems. These bands facilitate an even greater reduction in aperture size and can utilize technology and components of lower frequencies because of their harmonic relationship. Preliminary analysis shows technical feasibility. These bands are needed because, in the future, anti-collision type radars will have to integrate into more aerodynamic body styles with both reduced grille and overall vehicle profile. The requested bands are 2 GHz wide to allow a large system capacity for open entry to many users.

2.2 INTERFERENCE

Protection from interference is essential to proper operation for the benefit of the general public. The electromagnetic (EM) interference that a device generates must not exceed a level at which radio and telecommunications equipment and other automotive radar devices will fail to operate as intended. Also, these devices will require an adequate level of intrinsic immunity from electromagnetic disturbance to enable them to operate as intended.

AAMA members have long recognized the above and are currently using various techniques that will assure non-interference. Low probability of intercept (LPI) techniques such as spread spectrum and frequency hopping are expected to be employed. By hopping within a spectrum spread throughout the 1 GHz band, the probability of two systems within range of each other transmitting at the same frequency is very low. By using different hop sequences for like systems, the probability of intercept is further reduced. Other LPI techniques, such as signal matching techniques, render similar results. The probability of interference is further lessened by the fact that these systems are highly directional and mobile. Most systems operate with less than a three degree beamwidth. All these characteristics will provide reliable operation with both like and unlike systems permitting multiple in-band use.

The effects of specific requirements cannot be determined until the frequency bands and operational limits are established and can be evaluated. Note that it is not the intention of the AAMA to suggest the FCC propose design criteria, but rather the FCC propose interference performance criteria.

2.3 ELECTROMAGNETIC COMPATIBILITY

While a radar system has unique characteristics, it is intended to become one of many electronic subsystems on a vehicle. Unlike most electronic subsystems on a vehicle, it has both unintentional and intentional radiator characteristics. Industry standards (SAE J551 & SAE J1113) and practice are in place to ensure electromagnetic compatibility of vehicles with the surrounding environment.

2.4 TEST COMMENTS

47 CFR Part 15 Subpart C, Intentional Radiators, does not at the present time cover all of the frequencies requested by AAMA. With the low power associated with the automotive millimeter wave subsystems, Subpart C with modification, another part or a new section could serve as a basis for controlling the intentional radiator parameters of these vehicular subsystems. We recommend, however, that the approval of devices, if required, be done on a stand-alone device basis (i.e. not an in-vehicle test).

Tests for radar systems would potentionally include: frequency, power output, frequency stability as a function of temperature and supply voltage, and spurious and harmonic output levels.

Specific methods for performing these tests at the requested frequencies do not exist in the current version of ANSI C63.4. However, comparable test methods at lower frequencies could serve as the basis for testing at higher frequencies. We would propose that AAMA work with ANSI through the Society of Automotive Engineers (SAE) committees to

develop appropriate test methods in conjunction with the FCC.

3.0 CONCLUSION

To provide for vehicle radar system benefits such as improved safety resulting in, reduced traffic congestion and ancillary benefits, timely specifications are required on IVHS vehicle radar electromagnetic spectrum, operational limits, and test protocol. AAMA submits that when the issues addressed in these comments are defined by the FCC, AAMA members can initiate the development of vehicular radar on a more certain basis.

AAMA and its members are available to discuss any or all of these comments at the convenience of the FCC staff.

Respectfully submitted,
AMERICAN AUTOMOBILE
MANUFACTURERS ASSOCIATION

Date February 3, 1994 by _____

Attachment (1)

AMA SERVICE LIST - RM-8308

Lois A. Williams, Vice President
General Motors Research Corporation
12-121 General Motors Building
3044 West Grand Boulevard
Detroit, MI 48202

4350 North Fairfax Drive
Suite 900
Arlington, VA 22203
Attorneys. for Sobocomo Radio, Inc.

John Crigler, Esq.
Haley, Bader & Potts

Dale E. Dawkins
Chrysler Corporation

Featherstone Road Center
2301 Featherstone Road
Auburn Hills, MI 48326-2808

David Tillotson, Esq.
3421 M Street, N.W.
Suite 1739
Washington, D.C. 20007
Attorneys. for American Radio
Brokers, Inc.

Susan Wing, Esq.
Christopher P. Gilkerson, Esq.
Hogan & Hartson
Columbia Square
555 Thirteenth Street, N.W.
Washington, D.C. 20004-1109
Attorneys for VORAD Safety
Systems, Inc.

Richard E. Wiley, Esq.
David E. Hilliard, Esq.
Carl R. Frank, Esq.
Wiley, Rein & Fielding
1776 K Street N. W.
Washington, D.C. 20006
Attorneys for Ford Motor Company

Roger L. May, Esq.
Mark Mollon, Esq.
Ford Motor Company
911 Parklane Towers East
Dearborn, MI 48126